**Codsall Sewage Treatment Works** FilterClear process providing a low whole life cost solution for phosphorus removal to comply with the Water Framework Directive by Dr Caroline Huo, Suzie Vale, Atul Patel, Kristian Roberts & Alex Wohling

Severn Trent (ST) and Hafren Dyfrdwy (HD) have been challenged to meet a large number of new, tight phosphorus permits as a result of the Water Framework Directive (WFD). Historically, only Total-P levels down to 1 mg/l have been enforced by the Environment Agency, but in AMP6 and AMP7 a big step change in expectations has been seen with permit levels as low as 0.1 mg/l Total-P being introduced. ST and HD have committed to improve the effluent Phosphorus quality of 265 of their sewage works. Implementation of the WFD commenced at the end of 2009 and must be completed by 2027 so the majority of the work is being undertaken over AMP6 and AMP7 (103 sites in AMP6 and 162 in AMP7, including 3 for Hafren Dyfrdwy).



# Trials/background

Rather than solely targeting the more relaxed P permits in AMP6, leaving the more challenging tighter permits until AMP7, when more learning would have been gained, ST made the bold decision to commit to a large number of the tighter permits in AMP6 despite knowing that technologies would need to be selected prior to the outputs from the National P trials.

In order to assess the performance and reliability of the different technologies available, a large trial site was established at Packington STW which trialled a range of both market-ready and longer term technologies including dosed cloth filter, ballasted coagulation, membranes, algae, reed beds and ion exchange.

The data from this and other trials including a dosed continuously operating upflow filter (COUF) at Bucknell, a dosed deep bed sand filter (DBSF) at Packington, a BluePro at Shirebrook, dosed fuzzy filters at Brancote and dosed membranes at Buxton, fed into the development of their *Low P Process Selection Matrix* which informs which technologies are suitable for each project. The final process selection is then determined based on whole life cost (WLC).

Phosphorus removal processes are often heavily reliant on chemicals to precipitate out phosphorus from the sewage. In order to reduce their chemical consumption and reliance on chemicals which can at times be in short supply, ST always appraise the suitability of biological phosphorus removal for each project using the learning from their numerous enhanced biological phosphorus removal (EBPR) plants installed in previous AMPs.

In recent years, phosphorus discharge limits have been tightened globally to improve the surface water quality, particularly to address eutrophication issues. In the UK, phosphorus has been identified as the primary reason for the receiving water not achieving 'good status' required by the WFD. Over recent years total phosphorus permits have been tightened from 1 or 2 mg/l to 0.5 mg/l or below.







FilterClear vessel showing media arrangement Courtesy of Bluewater Bio

Phosphorus can be removed biologically or chemically. In countries like South Africa and China, bio P removal is the common approach, supplemented by chemical dosing when the TP limit is below 0.5 mg/l. In the UK however nearly 90% of the sewage treatment works are below 10,000 PE, many of these are tricking filter works which makes a BioP solution highly challenging. Consequently, chemical P removal has become the predominant solution. To achieve TP of 0.5 mg/l or less, the majority of water companies specify a 2-point chemical dosing regime, coupled with a tertiary solids removal (TSR) stage.

Across the Severn Trent region, MMB has delivered fifteen AMP6 projects where phosphorus removal has been a quality driver. These have ranged in size from small sites with a population equivalent (PE) of less than 1000 to large sites with a PE of more than 130,000 and have included installation of a range of TSR technologies and chemical dosing systems. Codsall STW was one of the first AMP6 projects to be delivered by MMB for phosphorus removal, starting outline design in late 2015.

# Codsall STW

Codsall STW is a medium sized works located near the village of Bilbrook, north of Wolverhampton, serving a PE of approximately 17,000. The works comprises two treatment streams; an activated sludge stream and a trickling filter stream. The flow to full treatment (FFT) is 82 l/s; the discharge permits were: TSS 40 mg/l, BOD 20 mg/l, Ammonia 5/10 mg/l. Under the WFD in AMP6, the site has to meet a new total phosphorus permit of 0.5 mg/l (annual average) and Fe of 4 mg/l (95%ile).

To achieve these new permit standards, Severn Trent has decided to apply 2-point chemical dosing and install a TSR plant.

MMB undertook detailed option studies, considering aspects such as process reliability, delivery programme, and the WLC. In keeping with Severn Trent's driver for best TOTEX (combined OPEX and CAPEX) solution, the WLC analysis considered the various tertiary technology's capital cost as well as electrical and chemical usage and maintenance/overhaul requirements.

FilterClear was identified as the preferred solution based on whole life cost and Design for Manufacturing and Assembly (DfMA) assessments and Bluewater Bio was awarded the contract to install a plant comprising four filters for tertiary TP removal.

Other works completed at Codsall along with the TSR installation included:

- A new coagulant dosing system (to feed both the inlet works and TSR with ferric sulphate).
- Increased co-settled sludge consolidation to manage the increase in sludge from the TSR.
- Dirty TSR backwash attenuation capacity to prevent the new TSR from flooding the existing works returns system.
- Various capital maintenance activities.

### FilterClear technology: four-media high rate filtration

FilterClear is a four-media depth filtration technology. The influent is pumped to the top of the filter and flows through 4 layers of media: Anthracite, Silica, Alumina and Magnetite, which have decreasing particle size and increasing density.

This configuration provides an equivalent of 4-stage filtration in a single vessel, allowing the filter to operate at a much higher filtration rate (up to 35m/h) and achieve a better effluent quality than conventional sand filters.

The key benefit of depth filtration is to enable the solids to be removed progressively through the entire depth of the 4-layer filter bed, hence this achieves a longer run-time and reduces backwash frequencies. The layer structure is maintained after backwashing due to the carefully selected density and particle sizes of the 4 media layers.

FilterClear has an average operating pressure of 0.4 bar, offering a low energy demand and a low operational carbon footprint. It only requires coagulant dosing for P removal; no polyelectrolyte or ballast material is required.

## Flocculation

For chemical P removal, good coagulation and flocculation are critical. Many TSR technologies need purpose-built coagulation and flocculation tanks with mechanical mixing, and some of them require polymer dosing.

In comparison, as large flocs are not preferred for depth filtration, a flocculation tank or mechanical mixing is not required by FilterClear. Chemical dosing can be added directly upstream of the FilterClear plant via an in-line static mixer and flocculation will occur in the headspace inside the filter vessel, above the media bed. This makes the process simpler to build and operate and eliminates the associated operational and maintenance tasks.

### **Project scope**

The FilterClear plant is designed to meet the 0.5 mg/l TP discharge permit. Various requirements were taken into account:

- To treat the peak flow while one filter is in backwash.
- To minimise the whole life cost and footprint.
- To ensure the minimum runtime is adequate under the worst-case scenario.
- To manage the interfaces with tertiary pumping and chemical dosing.
- To enable safe and easy ALM (access, lifting and maintenance).

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All of these requirements had to be balanced with the overall costs of the project. Throughout the project delivery, efficient and constructive communications were maintained with MMB and Severn Trent.

A new tertiary pumping station was designed and constructed by MMB to lift the secondary treated effluent to the tertiary plant. A ferric dosing plant (by others) was installed to provide 2-point dosing; the first point is upstream of the existing primary settlement tanks and the second point is upstream of the FilterClear plant.

Two non-ragging static mixers (duty/standby) were installed upstream of the FilterClear plant to provide in-line mixing of ferric sulphate with the pumped flow.

The FilterClear plant includes:

- 4 (No.) filters, each with a diameter of 2.04m and 3.6m high.
- Two backwash pumps (duty/standby).
- Two air scour blowers (duty/standby).
- A clean backwash tank.
- A dirty backwash tank.
- Pipework, actuated valves, instruments and controls.

As the captured suspended solids accumulate in the filter bed, the pressure increases gradually from 0.2 bar to 0.9 bar. Filter backwashing is initiated when the inlet pressure reaches a preset value, or on timer control. These values were set at the time of commissioning and are operator-adjustable.

Backwashing takes approximately 15 to 20 minutes (including air scouring). The filtered water is drawn from a clean backwash tank by the backwash pumps. The dirty backwash will have an average TSS concentration of between 300-500 mg/l and is discharged to the dirty backwash tank, then returned to the head of the works.

# An ideal solution to remove phosphorus from wastewater.

FilterClear

# **KEY FEATURES & BENEFITS:**

Excellent effluent quality (TP <0.1 mg/L) High filtration rate giving a reduced footprint

> High solids holding capacity & low backwash volume

Minimum civil works enabling quick on-site installation

Skid-mounted system, pre-assembled & tested off site Fully automated system, minimal

operational intervention

FIND OUT MORE:

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Bluewater Bio

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Supply Chain	Company
End user/client	SEVERN
	TRENT
Capital delivery partner	MMB MOTT MACDONALD BENTLEY
Process technology provider	

As developer and owner of the technology Bluewater Bio have a deep understanding of the process and consequently are able to provide a TP guarantee in addition to the solids guarantee as requested by the client. This offers the end user and their partners the simplest and clearest assurance of meeting the final effluent permit as well as being contractually most straight forward.

## Delivery, installation and O&M

Increasingly, Tier 1 partners are looking to minimise site construction activities and durations whilst maximising factory assembly and testing. This DfMa approach ensures both quality and safety are well controlled and ultimately delivers a better solution in a shorter time at a lower overall cost. FilterClear TSR plants are designed to permit factory assembly and testing, then delivery to site as a package plant. Where possible, the complete filter gallery, including backwash pumps, blowers, actuated valves, instruments and controls are skid-mounted and transported fully assembled. Site activities are then limited to coupling the filter vessels and adding the media.

Access to Codsall site is via a single-track road between a football pitch and a play area with a number of concealed crossing points. The FilterClear plant was delivered to the site on two lorries, one carrying four filter vessels, the other containing the skid-mounted package plant. Once on site, the plant was off-loaded and installed on a concrete slab within a few hours.

The compact nature of the FilterClear solution makes it an ideal fit on site. The FilterClear footprint is kept to a minimum using an inline static mixer to disperse the ferric rather than the requirement for separate flocculation tank and mechanical mixing.

Health and safety was an integral part of the design process, ensuring that all equipment is safe to install, operate and maintain. Throughout the project, the design teams worked closely with ST on the ALM assessment to ensure that the plant is operatorfriendly. Particular attention was paid to eliminating hazards during operation and maintenance.

Filtration and backwash of the FilterClear plant is fully automated, with minimum operational input. The filters are enclosed, with no moving parts or serviceable components within the vessels and need minimal operator intervention. Due to the enclosed, fully automated design, risk of operator exposure to wastewater or chemicals is minimised. Furthermore all machinery is at ground level for easy access.

### **Future-proof**

The FilterClear plant has been in operation since February 2018 and is comfortably achieving the required 0.5 mg/l TP, and the ferric dosing rate at Codsall is significantly lower than anticipated for the required TP permit limit. This will both provide OPEX savings, and importantly, will future-proof the works should permit tighten in the future. As part of Severn Trent's continuous improvement ethos, the capability of the FilterClear plant at Codsall STW to achieve a TP limit of less than 0.1 mg/l will be tested over the coming months.

Nationally, TP permits will continue to be further tightened. In AMP7, it is forecast that over 700 sites will be given more stringent TP permits. The EA set a technically achievable level of 0.25 mg/l for

TP, though Bluewater Bio's FilterClear technology is able to reach tighter TP discharge limits if needed.

## Summary

With smaller STWs increasingly being required to meet tighter TP permits, tertiary removal technologies will continue to evolve and improve over the years to come. Other challenges facing the industry include the needs for increased reliability on largely unmanned sites and to minimise the use of chemicals, whilst meeting increasingly stringent permit levels.

The editor and publishers would like to thank Dr Caroline Huo, Principal Process Engineer with Bluewater Bio, Suzie Vale, Senior Process Designer, and Atul Patel, Project Manager, both with Severn Trent, and Kristian Roberts, Project Leader, and Alex Wohling, Process Engineer, both with Mott MacDonald Bentley, for providing the above article for publication.







The fully-commissioned FilterClear plant - Courtesy of Bluewater Bio